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FOCUS DEVELOPED AN OPERABILITY AND RELIABILITY SURVEY FOR THE T-THERMAL SQI SYSTEM. THIS SURVEY WAS USED TO GATHER DATA FROM ELEVEN T-THERMAL SQI UNITS LOCATED IN THE CONTINENTAL UNITED STATES AND PUERTO RICO WHICH ARE INCINERATING AQUEOUS LIQUIDS WHICH WERE THE MOST SIMILAR TO BASIN F LIQUID.

THIS REPORT SUMMARIZES THE RESULTS OF THIS SURVEY.

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FocusEnvironmental
INCORPORATED
Engineering Solutions to Environmental Problems

OPERABILITY AND RELIABILITY SURVEY OF THE T-THERMAL SUBMERGED QUENCH INCINERATOR

SUBMITTED TO:

MORRISON-KNUDSEN ENGINEERS, INC.
DENVER, COLORADO

SUBMITTED BY:

FOCUS ENVIRONMENTAL, INCORPORATED
KNOXVILLE, TENNESSEE

PROJECT NUMBER 118903

FEBRUARY 19, 1990

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EXECUTIVE SUMMARY

There are eleven T-Thermal Submerged Quench Incinerators (SQI) in the United States and Puerto Rico which have operational experience with organic and salt containing liquid similar to the Basin F liquid. Focus Environmental, Inc. surveyed company personnel who were involved with all of these units. The survey was done by phone and included a visit to one unit.

The survey indicated that the Nittetu/T-Thermal SQI system is a commercially proven technology with 116 world-wide installations since 1970. The technology, which also has application to vent gases and organic liquids, is particularly well suited to the treatment of organic and salt containing aqueous liquids.

Nine of the eleven units surveyed have hazardous incinerator Resource Conservation and Recovery Act (RCRA) permits, and automatic liquid feed cut-off systems based on permit conditions. Five of the nine RCRA units have done successful trial burns. Four other permitted RCRA units received permits based on test data from similar systems. Two units are permitted under state air regulations.

Relative to operability and reliability, defined in terms of the down time needed for repairs, the incinerators surveyed had the following reliability factors:

- Incinerator 1 80 to 90%
- Incinerator 2 80 to 90%
- Incinerator 3 80 to 90%
- Incinerator 4 96 to 97%
- Incinerator 6 93%

Incinerators 5, 9, 10, and 11 have not had enough liquid feed to allow continuous operation and establishment of a reliability history. Incinerator No. 7 was moved in 1986 or 1987 from its original location to a new location where it is now being started up. There was no one available at the first location who had operational experience with this incinerator. These reliability factors indicate that the T-Thermal SQI design has good operability and reliability while treating organic and salt containing aqueous liquids.

The most common operability and reliability problems identified during the survey are listed below. None of these maintenance activities were considered to be major problems by the respondents. Most of the respondents have preventive maintenance programs which they feel are very important to achieve high reliability and minimize operating problems.

- Salt and solids buildup in the quench tank
- Hot spots in the incinerator steel shell caused by refractory failure
- Corrosion and plugging of the Vortex burner nozzle

- Plugging of the aqueous nozzles
- Refractory replacement, typically on a scheduled annual basis
- Thermocouple replacement

Based on the results of this survey and the site visit to Incinerator No. 4, Focus feels that the proposed T-Thermal SQI, which will have equivalent design to those surveyed, will have good operability and reliability if it is used to incinerate the Basin F liquid.

1.0 INTRODUCTION

Morrison-Knudsen Engineers, Inc., (MKE) is providing litigation support, engineering, technical, scientific, and other expert services in connection with the activities of its client, Holme Roberts & Owen for the Rocky Mountain Arsenal Project. As part of these activities, MKE has asked Focus Environmental, Inc. (Focus) to provide an operability and reliability survey of the T-Thermal Submerged Quench Incinerator (SQI) System which is being recommended for the treatment of the Basin F liquids.

Focus developed an operability and reliability survey for the T-Thermal SQI system. This survey was used to gather data from eleven T-Thermal SQI units located in the continental United States and Puerto Rico which are incinerating aqueous liquids which were the most similar to Basin F liquid. Focus also visited one of these units for an in-depth discussion of operability and reliability. This report summarizes the results of this survey.

2.0 SCOPE

The scope of this study included the following activities:

- Development of a list of T-Thermal SQI liquid incineration systems in the United States and Puerto Rico which are incinerating wastes similar to Basin F liquids;
- Development of an operability and reliability survey form;
- Use of the survey form to gather data from the T-Thermal SQI facilities located in the U.S. and Puerto Rico;
- Selection and a visit to one of the T-Thermal SQI facilities for an in-depth operability and reliability evaluation;
- Summarize the results of the operability and reliability survey in a report.

3.0 T-THERMAL SQI TECHNOLOGY

3.1 Nittetu License

The T-Thermal (SQI) technology is licensed from Nittetu Chemical Engineering, LTD., (Nittetu) a Japanese firm. Nittetu and T-Thermal have installed 116 of these SQI units throughout the world since 1970, with about 21 located in the U.S. and Puerto Rico. Table 3-1 lists the distribution of installed SQI units by country. The SQI units range in size from less than 1 to over 200 million (MM) Btu/hr. A one MM Btu/hr SQI incinerator could treat about 36 gallons per hour (gph) of Basin F liquid, and a 200 MM Btu/hr unit could treat about 7500 gph. The proposed SQI incinerator will be about 24 MM Btu/hr and will be designed to treat about 900 gph of Basin F liquids.

The first SQI unit was installed in the U.S. in 1973. Over 75% of the 116 units are used by the chemical and pharmaceutical industry. Eleven of these 21 T-Thermal SQI units in the USA are incinerating liquids similar to the Basin F liquid. These eleven units are permitted only for liquids generated by the company at the facility where the SQI is located. The other ten units are being primarily operated on process vent gases and organic liquids without aqueous brines.

3.2 T-Thermal SQI Uses

The T-Thermal SQI unit is used for the treatment of aqueous liquids containing organics and salts (brines). It is also used for chlorinated organics because its design can minimize the formation of free chlorine[1]. The Basin F liquid is an aqueous brine containing organics which cannot be biologically treated because of the presence of the salts. The SQI unit has special design features to handle these kinds of liquids[1]. The T-Thermal Vortex burner has a short turbulent flame which is stable and reliable even on poor quality fuel. Special aqueous atomizers break up the brines into small droplets which evaporate quickly. The incinerator can be closely controlled to maintain a good oxidizing reaction. The vertical sides of the incinerator are designed to allow molten salts to run down the walls and into the quench tank. In the quench tank, the salts are continuously washed into solution for easier removal as a liquid brine.

3.3 Process Description

Figure 3-1 is a representation of the T-Thermal SQI incinerator and hot combustion gas quench tank. Non-combustible aqueous or brine is pumped to multiple atomizing jets located in the side of the incinerator which is a cylindrical carbon steel shell lined internally with corrosion resistant refractory bricks. The aqueous liquid is atomized with either steam or compressed air. Natural gas, fuel oil or organic liquids are fired vertically downwards in a high intensity burner called a Vortex burner located at the top of the incinerator. This burner is used to maintain operating temperatures in the incinerator which can be in the range of 1600 to 2200^{o}F depending on liquid composition and regulations.

Table 3-1. Distribution of Nittetu and
T-Thermal Submerged Quench Incinerators by Country

Japan	69
United States and Puerto Rico	21
W. Germany	2
Korea	1
Brazil	3
Turkey	1
China	4
Singapore	1
Republic of South Africa	1
Czechoslovakia	2
Taiwan	3
Saudi Arabia	2
Yugoslavia	1
USSR	2
Johnston Atoll/Pacific Ocean	1
Ireland	1
Hungary	1
	116

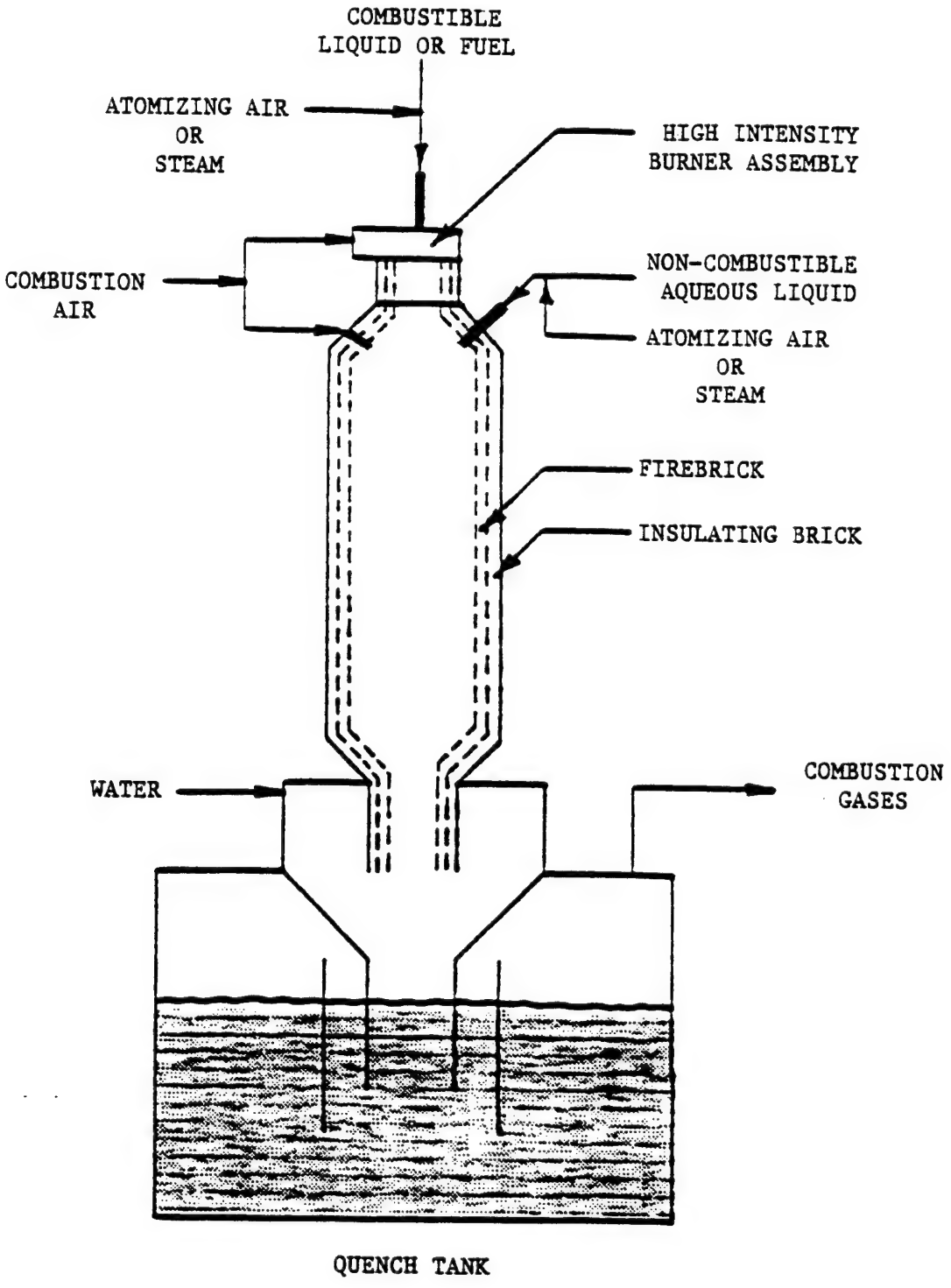

Figure 3-1. T-Thermal Submerged Quench Incinerator

The atomizing jets produce a fine mist of droplets which evaporate rapidly. The organic compounds are thermally destroyed in the high temperature environment and oxidized mostly to carbon dioxide and water. The inorganic salts dry and can become molten and flow down the walls of the incinerator.

The combustion gas and inorganic salts pass through the incinerator into a water irrigated downcomer and then into the quench tank where the combustion gases are rapidly cooled from the combustion temperature to approximately 190^{O}F. The combustion gas then passes to the air pollution control system which is generally a particulate removal device and/or an acid gas removal system. The treated combustion gas passes from the air pollution control equipment to the stack and out to the atmosphere. A high energy venturi for particulate removal and a packed bed with alkaline scrubbing for acid gas removal is a common air pollution control option on many existing T-Thermal SQI systems.

4.0 OPERABILITY AND RELIABILITY

An incineration system with good operability will achieve the required performance and desired production results with levels of operator and supervisory effort which are acceptable to the management of the treatment facility. An incineration system with good reliability is one which can be operated for acceptable periods of time on the intended liquids without having to be shut down for unexpected maintenance and repairs. In industry, a minimum acceptable reliability would be about 70% operation and 30% downtime for maintenance.

Operability and reliability are important issues relative to the operation of the proposed T-Thermal SQI system for the treatment of the Basin F liquid. Operability of the proposed T-Thermal SQI unit is important because if the system doesn't work, another solution will need to be developed and implemented. Reliability is important because an operable system with poor reliability will take longer to dispose of the intended liquids.

Reliability is also important because frequent process upsets and unscheduled maintenance shutdowns could result in slightly higher emissions from the incineration system during these incidents.

An incineration system with a reliability of 45% will take twice as long to dispose of the same amount of liquids as one with a reliability factor of 90%. Industrial incineration systems typically have reliabilities of 80 to 95%. Liquid incineration systems have the highest reliabilities because they have relatively simple designs and do not have complex materials handling requirements.

5.0 T-THERMAL SQI INCINERATOR SURVEY

In order to evaluate the operability and reliability of the T-Thermal SQI system relative to the Basin F liquid a survey was designed and used to develop information on SQI Systems located in the United States and Puerto Rico. The survey and the information obtained on these systems is described in this section.

5.1 Selection of Incinerators

The incinerators which were included in the survey were selected based on a discussion with T-Thermal. Of the 21 T-Thermal SQI units located in the United States and Puerto Rico, eleven were selected as survey candidates because they were incinerating organic containing aqueous brines which were similar to the Basin F liquids. Survey responses were obtained on all of the eleven SQI's. The eleven SQI's were located at eight different manufacturing facilities.

5.2 Survey Information

The survey included the following areas:

- Type of liquids incinerated
- Incineration configuration
- Resource Conservation and Recovery Act (RCRA) permit status
- RCRA trial burn data
- Operations information
- Maintenance information
- General comments

Relative to operability and reliability, these areas were important for the following reasons.

5.2.1 Type of Liquid

The type and characteristics of the liquid feed are the most important factors in the selection and design of an incineration system and the subsequent operability and reliability of that system[2]. A liquid for example containing high amounts of organic chlorine will generate corrosive hydrogen chloride (HCl) in the combustion gas when incinerated. If this high organic chlorine is not considered in the design, the incinerator materials of construction will require excessive maintenance resulting in poor reliability. The Basin F liquid is an aqueous brine with a high salt content. The impact of a salt content on the operability and reliability of existing T-Thermal SQI's was explored during the survey data gathering.

5.2.2 Incinerator Configuration

The incinerator configuration includes such areas as its size, whether it is vertical and downfired, and the type of Air Pollution Control (APC) system. This information was assessed to determine if the proposed Basin F incinerator size was similar or dissimilar to existing SQI installations. A similar size would indicate that a proven design and system components could be used on the proposed Basin F liquid incinerator. Knowledge of existing T-Thermal SQI APC systems was assessed to see if these APC systems could meet state and Federal particulate emission standards on liquids similar to the Basin F liquid.

5.2.3 RCRA Permit Status

The proposed Basin F liquid incinerator will be operated in substantive compliance with the RCRA incinerator regulations. Incinerator operating standards are developed under a permitting process which includes a trial burn. The trial burn is a testing program used to demonstrate that emission requirements can be met. Because the Basin F incinerator is part of a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) on-site response action, no permit will be required. However, the Basin F liquid incinerator will be subject to a standard setting process almost identical to the permitting process and a trial burn will be conducted to ensure that during regular operations all air emissions requirements will be met.

During operation of the Basin F incinerator, conditions such as incinerator temperature will be monitored with instruments and tied into a control system which will automatically stop the feeds to the incinerator if the incinerator temperature gets too low. Because the Basin F incinerator will be subject to a standard setting process almost identical to the RCRA incinerator permitting process, the impact of this process on incinerator operability and reliability was addressed in this survey.

5.2.4 RCRA Trial Burn Data

A trial burn is performed as part of the EPA's hazardous incineration regulations[3] to assess the ability of an incinerator to pass the organic destruction, particulate emission and hydrogen chloride (HCl) removal performance standards. The regulations require an organic Destruction and Removal Efficiency (DRE) of at least 99.99%, particulate emissions equal to or less than 0.08 grains per dry standard cubic foot corrected to 7% O_2 (.08 gr/dscfc) and at least 99% removal of the HCl leaving the incinerator[4]. The passing or failing of the performance standards by the T-Thermal SQI units surveyed is an indicator of operability.

5.2.5 Operations Information

In this area the survey respondents were asked how long their units had been in operation, how many hours per year the T-Thermal SQI units operated on the average, and what

were the most common operational problems that caused the unit to have to stop feeding liquids and shutdown. This part of the survey was an important indicator of operability.

5.2.6 Maintenance Information

In this section of the survey, the respondents were asked about the main maintenance problems that occurred with the T-Thermal systems and the magnitude of the problem. This part of the survey was a very important indicator of equipment reliability.

5.2.7 General Comments

In this section of the survey the respondent was asked about his general impression and feelings about the T-Thermal SQI system. The responses were an important indicator of operability of these systems.

5.3 Survey Results

In order to improve responsiveness to the survey, Focus told the survey respondents that their company identities would be kept confidential. Because of this, the companies and incinerators surveyed and discussed in this report are identified only by number.

As part of the survey process, Incinerator Number 4 was visited for an indepth interview and discussion of operability and reliability. Incinerator 4 was selected for the visit because it was similar to the proposed Basin F incinerator in the following ways:

- Similar liquids (aqueous brine containing pesticides)
- Similar configuration (vertical SQI with air pollution control equipment)
- Trial burn (completed and successful)
- Long term operational history (running since 1976)

The survey responses are summarized in this section and Table 5-1 as follows:

Incinerator 1 - This unit was the first SQI system installed in the United States by T-Thermal in 1974. The unit is still operational and is incinerating aqueous pharmaceutical liquids with organic concentrations ranging from 10 to 30%. The salt concentration is generally 5% or less. The unit is a 70 MM Btu per hour system designed for about 2400 gph of aqueous feed. The combustion chamber is not vertical, but is essentially horizontal with a slight downward slope to the SQI quench tank. The APC system is a high energy venturi, permitted at a pressure drop of 66 inches of water column (W.C.)

This system has a RCRA permit and has successfully met the performance standards during a trial burn. During the trial burn the system achieved greater than 99.999% DRE's, had less than 0.08 gr/dscfc particulate emissions, more than 99% HCl removal and carbon

Table 5-1. Summary of Survey Results for SQI Incinerators

Incinerator Number	1	2	3	4	5	6	7	8	9, 10, 11
Thermal Duty (MM Btu/hr)	70	70	70	48	5	115	24	24	11
Brine Feedrate (gal/hr)	2400	2400	1800	1800	300	3000	900	900	400
Liquid Feeds (weight %)									
Organic	10-30	10-30	<5	<3		20	<1	5-10	90
Salts	<5	<5	<8	7-10	[a]	5	<5	<3.5	Low
Water	65-85	65-85	>87	85-90	[a]	75	98-99	85-90	10
Vertical or Horizontal Incin.	Hor	Vert	Hor	Vert	Vert	Vert	Vert	Vert	Vert
Type of Air Pollution Control	Venturi	Venturi	Venturi	Venturi	Packed Bed	Quench Tank	Venturi	venturi	Venturi
Pressure drop (INWC)	66	66	70	56	10	–	–	60	54
Type of Permit	RCRA	RCRA	RCRA	RCRA	RCRA	Air	Air	RCRA	RCRA
Permit Status	Final	Final	Final	Draft[b]	Final	Final	e	Draft[b]	Final
CO CEM	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Other CEM	O_2	O_2	O_2	O_2	O_2	No	No	O_2	O_2
Automatic Liquid Cut-off	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Successful RCRA Trial Burn	Yes	C	C	Yes	Yes	No	No	Yes	Yes
Unit Operational Since	1974	1981	1976	1976	Early 80's	1984	1980[f]	1979	1978
Operator Factor (%)	80-90	80-90	80-90	96-97	d	93	g	90	d

[a] No longer feeding aqueous liquids.

[b] Public comment period closed, final permit expected in early 1990.

[c] Unit permitted based on test data from a similar system.

[d] Minimal operating history available. Unit has not run continuously until recently because of low amounts of liquids.

[e] Process change eliminated liquids: Unit was shutdown and moved to a second company location where it is now being started up.

[f] 1980 until 1986 or 1987.

[g] No one available at location 1 who had operational experience.

monoxide (CO) levels well below 100 ppm. The system has CO and oxygen (O_2) continuous emission monitors (CEMs) and an automatic liquid feed cut-off system. (See Section 5.2.3)

The unit operates on liquid feeds 80 to 90% of the time with no major operational problems. The refractory is replaced every 18 to 24 months in high corrosion areas and every four to eight years in areas with minimal liquid contact. There have been corrosion problems with liquid feed pipes and scrubber water piping. The survey respondent at this location was pleased with the operability and reliability of this system.

Incinerator 2 - This unit is located at the same location as Incinerator No. 1 and was installed in 1981. It is incinerating pharmaceutical liquids with organic concentrations ranging from 10 to 30%. The salt concentration is generally 5% or less. The unit is a 70 MM Btu per hour system designed for about 2400 gph of waste. The combustion chamber is vertical with a submerged quench. The APC system is a high energy venturi, permitted at a pressure drop of 66 inches W.C.

This system has a RCRA permit but has not had to perform a trial burn. The permit was obtained using test data from a similar incinerator. The system has CO and O_2 CEMs and an automatic liquid feed cut-off system.

The unit operates on liquid feeds 80 to 90% of the time with no major operational problems. The refractory is replaced every 18 to 24 months in high corrosion areas and every four to eight years in areas with minimal liquid contact. There have been corrosion problems with liquid feed pipes and scrubber water piping. The survey respondent at this location was pleased with the operability and reliability of this system.

Incinerator 3 - This unit was installed in 1976 and has an identical design to incinerator number 1. The unit is incinerating aqueous pharmaceutical liquids with low organic concentrations typically below 5%. Organic liquids are also fed to the Vortex burner. Salt and ash concentrations can range up to 5% in the organic liquids and up to 8% salt in the aqueous. The unit is a 70 MM Btu per hour system designed for about 2400 gph of aqueous liquid and is currently handling about 1800 gph. The combustion chamber is not vertical, but is essentially horizontal and has a slight downward slope. The APC system includes the submerged quench, and a high energy venturi, permitted at a pressure drop of 66 inches W.C. It operates at about 70 in. W.C.

The unit has a RCRA permit, but has not been required to do a trial burn. It received a permit based on the submittal of test data from a similar incinerator. The unit has CO and O_2 CEMs.

The unit operates about 60 to 70% of the time because the facility does not have enough liquids to run it full time. When the unit is running, it has a reliability factor of 80 to 90%. The following operating problems are typically encountered:

- Corrosion of organic burner nozzles
- Plugging of organic burner and aqueous nozzles
- Refractory hot spots caused by corrosion
- Salt and solid build-up in the quench tank

The maintenance program for the unit includes annual refractory replacement which takes four to six weeks, nozzle cleaning and replacement, refractory patching and removing solid salt out of the quench tank about twice per year.

The incineration engineer responsible for the unit commented that he has evaluated all of the major types of incinerators designed for organic and salt containing aqueous liquids. He likes the design of the T-Thermal unit the best and believes it is a very safe unit to operate.

Incinerator 4 - This unit was visited on December 14, 1989. This unit has been operational since 1976. The unit incinerates pesticide and salt containing aqueous liquids and a number of vent gases from the pesticide manufacturing process. The pesticides are organophosphorous and sulfur containing compounds which are somewhat similar to Malathion, one of the Basin F contaminants. The aqueous liquids contain up to about 3% organics and 7 to 10% salts as sodium sulfate. During the RCRA trial burn the aqueous liquids contained 20% sodium sulfate. About 250 pounds per hour of organic pesticide liquid is fed to the Vortex burner as a fuel supplement. The unit is a 48 MM Btu per hour system which is treating about 1800 gph of the aqueous material.

The unit is a downfired SQI system as shown in Figure 3-1. The APC system includes the submerged quench, a cyclonic separator, a high energy venturi, another entrainment separator, and a packed bed scrubber. The venturi is permitted to operate at a minimum pressure drop of 56 inches W.C.

The unit is in the final stages of obtaining a RCRA permit and has successfully met the performance standards during a trial burn. The trial burn results are summarized in Table 5-2. The Principal Organic Hazardous Constituents (POHCs) during the trial burn were monochlorobenzene and perchloroethylene, both of which are considered to be very thermally stable according to the EPA's Thermal Stability Index[5]. During two of the three perchloroethylene runs, DRE's of 99.99998 and 99.99999% were achieved. The unit has CO and O_2 CEMs and a computer control system which is used to control the automatic liquid feed cut-off system. The incinerator process parameters which are incorporated into the permit and which shut down the liquid feed if exceeded, are summarized in Table 5-3.

The pesticide manufacturing process is shut down one month per year for maintenance, so the incinerator only runs eleven months per year. During these eleven months of operation, the unit which is also used as a process vent gas incinerator, must be operating or the pesticide process must be shutdown. During the visit, the incinerator engineer responsible for the T-Thermal unit estimated that the incinerator has an operating factor of

about 96 to 97% during the eleven months it is operating. The following problems have caused operational problems with the unit:

- Failure of the ultraviolet flame eye causing shutdown
- Infrequent plugging of aqueous nozzles
- Refractory failure in areas of high corrosion causing hot spots in the metal shell
- Salt and solid build-up in the quench tank about every 2 to 3 months

The automatic liquid feed cut-off system for incinerator 4 has not been an operational or reliability problem. The maintenance program for the incinerator includes a 2 to 4 week period during the pesticide process shutdown. During this period, refractory is replaced as appropriate, burner nozzles and aqueous nozzles are inspected, and the salts and solids are shoveled out of the quench tank.

The incinerator engineer at the plant commented that the T-Thermal unit has successfully incinerated over 12,000,000 gallons per year of aqueous liquids for each of the last 10 years. There are two other downfired incinerators made by a different vendor at the facility. These units are also treating pesticide and salt containing aqueous liquids. The incineration engineer at the facility prefers the T-Thermal over these units because he feels it is much easier to control. A second T-Thermal unit is on order and will be installed in 1990 at the facility.

Incinerator 5 - This unit was installed in the early 1980's. It is currently incinerating organic pharmaceutical liquids, and a vent gas, but no aqueous. The organic liquids include chlorinated organics. The unit is a 5 MM Btu per hour system which can handle about 180 gph of aqueous. The combustion chamber is vertical with a submerged quench. The APC system includes the submerged quench and a packed bed, but no venturi.

The unit has a RCRA permit and has performed a successful trial burn while feeding a liquid containing 63% carbon tetrachloride to the Vortex burner and aqueous liquids to the non-combustible nozzles. The unit achieved 99.999 to 99.9999% DRE's on the carbon tetrachloride. The unit has a CO and O_2 CEM and an automatic liquid feed cut-off system.

Until recently, there weren't enough liquids at the facility to keep the unit running continuously. Therefore the unit does not have much history on operability and reliability. During the first few years of operation the unit did have some corrosion problems because of the chlorinated organic liquid feed. The main problem was corrosion of the downcomer duct connecting the bottom of the incinerator and the quench tank. Installation of a graphite downcomer solved this problem. This company operates another T-Thermal SQI unit at another location as a fume incinerator without aqueous. This unit experienced quench tank corrosion problems which were solved by going from a Kynar lined steel quench tank to a fiber reinforced plastic (FRP) quench tank.

Incinerator 6 - This unit was installed in 1984. It is incinerating aqueous liquids which have organic concentrations of about 20%, and salt concentrations of about 5%. The organic is mostly phenol and the salts are mostly sodium chloride. The unit is a 115 MM Btu per hour unit which is currently treating about 3000 gph of aqueous liquids. The combustion chamber is a downfired vertical unit with a submerged quench. The combustion gas vents directly from the quench tank to the stack.

The unit has applied for a Bevill exemption[6] because the liquids being generated are high volume and low toxicity. The unit probably will not be required to get a RCRA permit or do a trial burn because of the exemption.

No unusual operational or maintenance problems for the unit were identified by the survey respondent. A preventive maintenance program is in effect at the facility in which the incinerator is regularly shut down 2 days each month. During these 2 days, the quench tank is emptied of salt and solids, thermocouples are replaced, leaks repaired, and rotating equipment is lubricated. Refractory is changed once per year and a pyrometer is used on a weekly basis to look for hot spots. The monthly preventive maintenance program has resulted in improved operability and reliability.

Incinerator 7 - This unit was installed in 1980 and operated until 1986 or 1987. The unit was then moved from one state to another in 1987 or 1988 and reinstalled. The unit was moved because process changes at the first location resulted in elimination of the liquids being treated by the unit. During operation, the unit was incinerating aqueous liquids with low organic concentrations typically below 1%. Salt concentrations were low, typically less than 1% in the aqueous. The unit is a 24 MM Btu per hour system designed for about 900 gph of aqueous liquid. The combustion chamber is vertical. The APC system includes the submerged quench, and a venturi, but not a packed bed. The unit operated under an air permit with non-hazardous liquids. The unit did not have CO and O_2 CEMS

No one remained at the facility who had operated the unit when it was at the first location. The historical operating factor could therefore not be determined. A process engineer who had worked on the unit after its startup did remember that there had been some corrosion problems with the downcomer weir. This problem was solved by changing the materials of construction of the weir.

According to an employee involved in regulatory affairs, the unit never had any explosions or fires during its operation.

Incinerator 8 - This unit was installed in 1979. It is incinerating pharmaceutical liquids with organic concentrations ranging from 5 to 10%. The salt concentration is generally about 3.5% as sodium chloride. The unit is a 24 MM Btu per hour system designed for about 900 gph of aqueous liquids, and currently treating about 600 gph. The combustion chamber is vertical with a submerged quench. The APC system is a high energy venturi operating at a pressure drop of 60 inches W.C.

Table 5-2. RCRA Trial Burn Results for Incinerator 4

	RCRA Requirements	Trial Burn Results
Destruction Removal Efficiency	99.99%	
Monochlorobenzene		99.9997%[a]
Perchlorethylene		99.9993%[a]
Particulate Emissions (gr/dscfc)	0.08	0.054
HCl Removal Efficiency	99%	99.5

[a]At 1562°F

Table 5-3. Automatic Liquid Feed Cut-off
Permit Conditions for Incinerator 4

Permit Conditions
Maximum aqueous feed rate
Maximum incinerator thermal duty
Maximum liquid ash content
Maximum liquid organic chlorine content
Minimum combustion temperature
Maximum combustion gas velocity indicator
Maximum CO concentration (one hour rolling average)
Minimum water flow rate to venturi
Minimum pH of scrubbing water
Minimum pressure drop across venturi
Minimum water flow rate to packed bed

This system does not have a RCRA permit now, but will probably receive one in the first quarter of 1990. The unit had a trial burn in 1988 and successfully passed. The unit achieved DRE's greater than 99.999%, had particulate emissions of about 0.04 grains/dscfc, and an HCl removal efficiency of 99.99%. The system has CO and O_2 CEMs and an automatic liquid feed cut-off system.

The unit operates with an operating factor of over 90%. It is shut down about 20 days per year for repairs and preventive maintenance. Common maintenance items include plugging of nozzles, thermocouple replacement, and cleaning solids out of the quench tank about every 3 months. The SQI refractory is changed about every 3 years.

The manager of Incinerator No. 8 feels that the T-Thermal SQI is a good unit. It operates very well and is simple. He said that careful selection of materials of construction for his unit was important.

Incinerators 9, 10, and 11 - These units are all located at the same facility. Two were installed in 1977 and one in 1979. The units are each about 11 MM Btu per hour in size and are designed to treat about 400 gph of aqueous pharmaceutical liquids. The organics include flammable solvents which are mostly fed to the Vortex burner. The aqueous liquids contain very little salt. The combustion chamber is vertical with a submerged quench. The APC system is a high energy venturi, permitted at a pressure drop of 54 inches W.C.

These systems all have permits based on successful trial burn performance for one of the units. During the trial burn the system achieved greater than 99.99994% DRE's, had 0.03 gr/dscfc particulate emissions and 99.95% HCl removal. The POHC's were carbon tetrachloride, toluene and dichlorobenzene. The system has CO and O_2 CEMS and an automatic liquid feed cut-off system. (See Section 5.2.3)

The three units operate on liquid feeds about 60% of the time with no major operational problems. The units operate only 60% of the time because there are not enough liquids to keep the units operating more of the time.

The following operating and maintenance problems are typically encountered:

- Refractory replacement
- Downcomer corrosion
- pH control of the quench tank
- Venturi pressure drop control
- Aqueous liquid nozzle corrosion and plugging

The magnitude of these problems have been reduced by installing new aqueous liquid nozzles, replacing the downcomer with a new downcomer constructed of Hastelloy C, and installing a computer for better control of the venturi pressure drop and the quench tank pH.

6.0 CONCLUSIONS

There are eleven T-Thermal Submerged Quench Incinerators (SQI) in the United States and Puerto Rico which have operational experience with organic and salt containing liquid similar to the Basin F liquid. Focus Environmental, Inc. surveyed company personnel who were involved with all of these units. The survey was done by phone and included a visit to one unit.

The survey indicated that the Nittetu/T-Thermal SQI system is a commercially proven technology with 116 world-wide installations since 1970. The technology, which also has application to vent gases and organic liquids, is particularly well suited to the treatment of organic and salt containing aqueous liquids.

Nine of the eleven units surveyed have hazardous incinerator Resource Conservation and Recovery Act (RCRA) permits, and automatic liquid feed cut-off systems based on permit conditions. Five of the nine RCRA units have done successful trial burns. Four other permitted RCRA units received permits based on test data from similar systems. Two units are permitted under state air regulations.

Relative to operability and reliability, defined in terms of the down time needed for repairs, the incinerators surveyed had the following reliability factors:

- Incinerator 1 80 to 90%
- Incinerator 2 80 to 90%
- Incinerator 3 80 to 90%
- Incinerator 4 96 to 97%
- Incinerator 6 93%

Incinerators 5, 9, 10, and 11 have not had enough liquid feed to allow continuous operation and establishment of a reliability history. Incinerator No. 7 was moved in 1986 or 1987 from its original location to a new location where it is now being started up. There was no one available at the first location who had operational experience with this incinerator. These reliability factors indicate that the T-Thermal SQI design has good operability and reliability while treating organic and salt containing aqueous liquids.

The most common operability and reliability problems identified during the survey are listed below. None of these maintenance activities were considered to be major problems by the respondents. Most of the respondents have preventive maintenance programs which they feel are very important to achieve high reliability and minimize operating problems.

- Salt and solids buildup in the quench tank
- Hot spots in the incinerator steel shell caused by refractory failure
- Corrosion and plugging of the Vortex burner nozzle
- Plugging of the aqueous nozzles

- Refractory replacement, typically on a scheduled annual basis
- Thermocouple replacement

Based on the results of this survey and the site visit to Incinerator No. 4, Focus feels that the proposed T-Thermal SQI, which will have equivalent design to those surveyed, will have good operability and reliability if it is used to incinerate the Basin F liquid.

REFERENCES

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2. J.J. Cudahy, "Industrial Waste Characterization", presented at the First National Industrial and Institutional Waste-To-Energy Conference, Philadelphia, PA, November 13, 1986.

3. Code of Federal Regulations, 40 CFR 270.62.

4. 40 CFR 264.343.

5. Guidance on Setting Permit Conditions and Reporting Trial Burn Results, USEPA Office of Solid Waste and Emergency Response, Washington, D.C., EPA/625/6-89/019, January 1989, Appendix D.

6. Resource Conservation and Recovery Act, "Hazardous and Solid Waste Amendments of 1984", November 8, 1984, Sections 3001(b)(2) and (3).

7. Personal Communication, G. Irgang of T-Thermal to J. Cudahy, November 28, 1989.